INDOOR AIR QUALITY ASSESSMENT

Allendale Elementary School
180 Connecticut Avenue
Pittsfield, MA

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program

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Background/Introduction

At the request of Dr. Phillip Adamo and Ms. Roberta Orsi, Pittsfield Board of Health (BOH), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH), provided assistance and consultation regarding indoor environmental concerns at the Allendale Elementary School (AES), 180 Connecticut Street, Pittsfield, Massachusetts. The BOH request was prompted by concerns about possible contamination of the school's indoor environment in relation to a nearby disposal area containing soils contaminated with polychlorinated biphenyl compounds (PCBs).

On November 22, 2005, a visit to conduct an assessment of the AES was made by Michael Feeney, Director of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Elaine Krueger, Director of the CEH Environmental Toxicology Program (ETP) and Michael Celona of CEH's ETP accompanied Mr. Feeney to determine the best strategy for follow up testing for PCBs within the school. Ann M. Kuhn, Principal of the AES, accompanied CEH staff during this assessment.

The AES is a single-story, yellow brick building that contains two wings. The original building was constructed in 1951 (Picture 1). The building was renovated in 1999 to add a new wing of classrooms (rooms 14 -23 and a media center) (Picture 2). The 195l building was renovated at that time. A suspended ceiling was installed, univents were rebuilt in place and all windows and door systems were replaced. A crawlspace exists beneath the 1951 wing , which has access ports in several classrooms (Picture 3). It appears that the 1999 wing was constructed on a slab with no discernable crawlspace. Windows throughout the building are openable.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particulate matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

As discussed, MDPH staff also evaluated the building to determine appropriate locations of indoor sampling for PCBs. The sampling plan and methods as well as results of the PCB sampling are included as Appendix A of this report.

Results

This school houses approximately 360 pre-kindergarten through fifth grade students, and approximately 25 staff members. Tests were taken during normal operations at the school. Results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in seven out of thirty-four rooms surveyed. Most of these appear to be in classrooms within the 1951 wing. For this reason the ventilation system should be evaluated to determine if it is properly balanced. Please note that a number of areas sampled were not occupied, which can greatly reduce carbon dioxide levels   Fresh air in classrooms is supplied by unit ventilator (univent) systems. A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and/or cooled and provided to classrooms through a diffuser located on the top of the unit. Mechanical exhaust ventilation in classrooms is provided by a combination of ceiling-mounted (Picture 4) or wall-mounted (Pictures 5 and 6) exhaust vents ducted to rooftop exhaust fans.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room, while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing was likely when the building was renovated in 1999.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix B.

Temperature measurements ranged from 68^{o} F to 73^{o} F, with most areas within the MDPH recommended comfort range (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measurements ranged from 27 to 35 percent, which were below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A significant number of classrooms had water damaged ceiling tiles. There was no visible evidence however of mold growth or water damaged materials in any other area during this evaluation.

A number of sources for roof leaks exist in the AES. As reported by Ms. Kuhn, the roof of the original building was damaged by trespassers who skateboarded on the roof. This activity would be expected to cause mechanical damage to roof materials, which would then lead to leaks during rainstorms. In addition, roof areas that are most likely to experience leaks are those where penetrations through the roof plane exist (e.g., skylights, exhaust vents) and/or sections of the roof abut the exterior wall. In this case, it appears that these conditions exist above the water damaged ceiling tiles in classrooms in both wings. In general, where two dissimilar materials meet on the exterior of a building, the seam between these materials is likely to be a point source for water penetration. The installation of flashing allows for water to transition from one surface to the next. Without properly installed flashing, water can penetrate through the seam resulting in water damage and potential mold growth. For example, water damage in one classroom in the new wing was located in a section of the ceiling tile system that was roughly beneath an exhaust vent on the roof, which is the only penetration through the roof in the vicinity of this classroom. Ceiling tiles around the exhaust vent for the kiln were also water damaged, which can also indicate flashing problems for this vent system.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants.

Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. For the AES, indoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured outside the school were also ND.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 1 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 1 to 15 $\mu g/m^3$, which were below the NAAQS PM2.5 level of 65 $\mu g/m^3$ in all areas. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner; and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC-containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

The original building contains crawlspaces beneath its floor. In order to ascertain whether a pathway for air and associated pollutants exists for materials to migrate from the crawlspace into occupied areas, the interiors of several univents were examined. In the experience of CEH staff, holes through which univent electrical conduit and heat pipes pass are frequently unsealed, creating a direct pathway for crawlspace air to be drawn into classrooms. Examination of several univents found that the space around heat pipes and electrical conduit to be sealed with a sealant compound (Pictures 7 and 8). Univents are also equipped to filter both outdoor air and return air from classrooms. Each univent examined was equipment with three pleated filters that are installed with metal spacers that prevent air bypass between filters (Picture 9) and filter. Also of note were steel lids that cover crawlspace access ports that are located directly beneath univent return vents (Picture 10). Seals and holes in these lids appear to be unsealed. All holes and seams of these lids should be sealed to prevent crawlspace air migration into classrooms.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made:

1) Prevent access to the roof by trespassers.
2) Once the access to the roof is secured, repair the roof.
3) Replace water damage ceiling tiles.
4) Seal all seams and holes in crawl space lids.
5) Increase fresh air supply by univents.
6) Once both the fresh air supply is increased, the ventilation system should be re-balanced.
7) For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, continue to use a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is

recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8) Consider adopting the US EPA (2000b) document, “Tools for Schools”, to maintain a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

9) Refer to resource manuals and other related indoor air quality documents for additional building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH’s website: http://www.state.ma.us/dph/MDPH/iaq/iaqhome.htm.

References

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Picture 1

1951 Wing

Picture 2

1991 Wing

Picture 3

Crawlspace Access Port

Picture 4

Ceiling Mounted Exhaust Vent

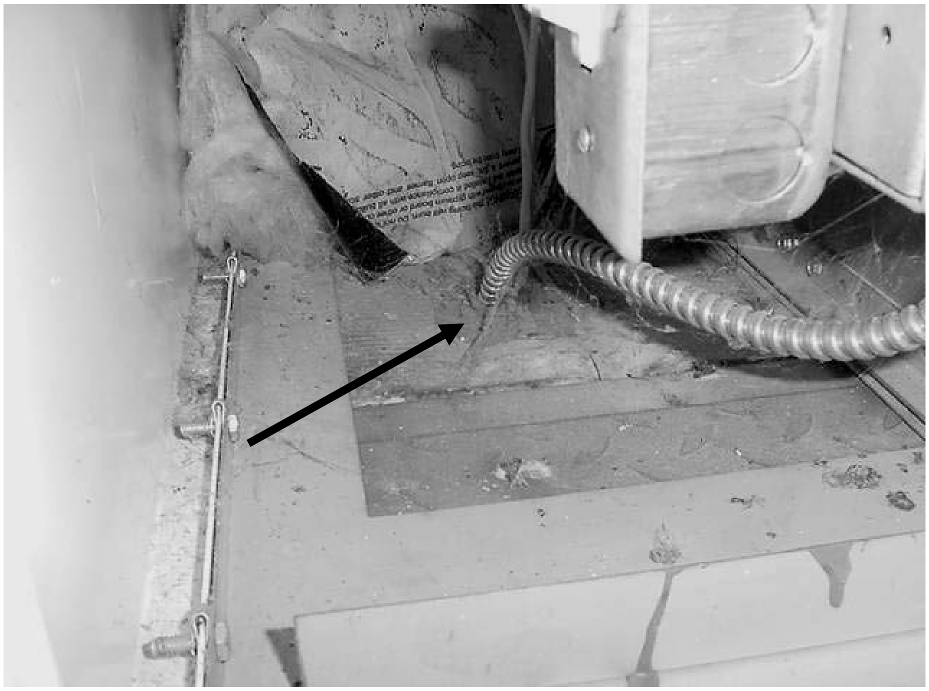
Picture 5

Wall Mounted Exhaust Vent, 1991 Wing

Picture 6

Wall-Mounted Exhaust Vent, 1951 Wing

Picture 7



Univent Electrical Conduit, Note Sealant (arrow)

Picture 8

Univent Heating Pipe, Note Sealant (arrow)

Picture 9

Univent Filters Equipped with Spacers

Picture 10

Crawlspace Access Portal Located Directly beneath Univent Return Vents

TABLE 1

Indoor Air Test Results

Allendale Elementary School, 180 Connecticut Avenue, Pittsfield, MA

November 22, 2005

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Ultra-fine Particulate	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Outdoors, back of building	360	ND	ND	1	< 32	87					
Outdoors, back of building	355	ND	ND	1	< 32	88					
10	520	ND	ND	1	72	29	0	Y	Y	Y	2 water damaged ceiling tiles
14	692	ND	ND	10	71	30	19	Y	Y	Y	
15	623	ND	ND	4	72	29	23	Y	Y	Y	
16	464	ND	ND	6	71	27	17	Y	Y	Y	
17	571	ND	ND	7	73	27	19	Y	Y	Y	1 water damaged ceiling tiles
18	593	ND	ND	1	73	27	15	Y	Y	Y	
19	558	ND	ND	1	73	27	14	Y	Y	Y	1 water damaged ceiling tiles
20	565	ND	ND	8	73	29	17	Y	Y	Y	5 water damaged ceiling tiles
21	596	ND	ND	5	73	29	20	Y	Y	Y	

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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November 22, 2005

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Ultra-fine Particulate	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
22	502	ND	ND	4	72	27	14	Y	Y	Y	
23	773	ND	ND	4	72	32	19	Y	Y	Y	
24	755	ND	ND	7	71	32	21	Y	Y	Y	7 water damaged ceiling tiles
25	858	ND	ND	15	71	32	19	Y	Y	Y	
26	545	ND	ND	2	71	28	14	Y	Y	Y	1 water damaged ceiling tiles
27	903	ND	ND	1	71	31	21	Y	Y	Y	5 water damaged ceiling tiles
28	512	ND	ND	1	71	29	0	Y	Y	Y	
29	808	ND	ND	7	71	30	16	Y	Y	Y	8
30	847	ND	ND	6	71	31	23	Y	Y	Y	3 water damaged ceiling tiles
31	851	ND	ND	3	71	31	23	Y	Y	Y	7 water damaged ceiling tiles
32	808	ND	ND	4	71	31	28	Y	Y	Y	1 water damaged ceiling tiles

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									Supply	Exhaust	
33	655	ND	ND	4	72	30	18	Y	Y	Y	11 water damaged ceiling tiles
8A	896	ND	ND	1	71	35	5	Y	Y	Y	
9 t	426	ND	ND	1	71	28	0	Y	Y	Y	3 water damaged ceiling tiles 3 water damaged ceiling tiles in kiln room
Cafeteria	608	ND	ND	10	71	33	11	Y	Y	Y	
Copy room	631	ND	ND	2	70	32	0	N	Y	Y	4 water damaged ceiling tiles
Guidance	527	ND	ND	14	71	29	0	Y	Y	Y	
Gym	597	ND	ND	5	72	29	26	N	Y	Y	
Health office	617	ND	ND	1	68	35	1	Y	Y	Y	1 water damaged ceiling tiles
Media center	363	ND	ND	2	68	28	0	Y	Y	Y	y
Office	727	ND	ND	2	71	38	1	N	Y	Y	

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									Supply	Exhaust	
Principal	614	ND	ND	1	66	38	0	Y	Y	Y	9 water damaged ceiling tiles
Reading room	629	ND	ND	3	71	29	3	Y	Y	Y	
Speech	576	ND	ND	1	69	29	0	Y	Y	Y	
Staff room	509	ND	ND	1	70	31	0	N	Y	Y	

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